RESTORATION STRATEGY FOR THE MERCED RIVER THROUGH YOSEMITE VALLEY

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INTRODUCTION

This white paper articulates the vision guiding planned and ongoing efforts to restore the Merced River through Yosemite Valley, and to explain the rationale for the measures being pursued to achieve that vision. The goal here is to provide the context for these restoration measures, so that stakeholders, practitioners, managers, and the general public can understand the basis for *what* is being undertaken, and *why* they are being done.

For guidance on the vision of the Merced River and its management by the National Park Service, the Merced River Plan offers clear direction:

> "*The overall goal of the Final Merced River Plan/EIS is to provide for public use and enjoyment of the river resource while protecting and enhancing the values for which the Merced River was designated a Wild and Scenic River*," values that include "*the river's free-flowing condition, water quality, and outstandingly remarkable values, collectively referred to as river values*." Such rivers and their immediate environments are to be protected for the benefit and enjoyment of present and future generations. (MRP, pp. ES-1 and 1-3)

The Plan further refined this overarching vision to specify four goals specific to Yosemite National Park (MRP, p. 1-3):

- Protect and Enhance Ecological and Natural Resource River Values
- Provide Opportunities for Direct Connection to River Values
- Establish a User Capacity Management Program
- Determine Land Uses and Associated Developments

Only the first of these goals is directly addressed by the river restoration work being planned and implemented, but that work is occurring within a broader context that includes visitor access and experience, and the acknowledgement of other activities that may not directly involve, but must nonetheless support, the "natural and cultural river values today and into the future."

A host of restoration efforts are planned or already being implemented along the Merced River, and they are being informed by a variety of prior and ongoing studies. The National Park Service made a first systematic survey of the extent and causes of bank erosion in the early 1990's, documenting the clear association of high visitor use with riverbank erosion and subsequent channel widening averaging 27% in areas with concentrated human use. The survey also pointed out potential problems with unnecessary bank armoring, bridge placement, and the systematic removal of large logs from the channel. A follow-up study in 2012 by the consulting firm Cardno Entrix documented similar conditions and identified the same suite of causal agents, noting that the 1997 flood of record had a particularly significant effect on both bank erosion and the introduction of large logs (from bank-eroded trees) into the channel. A survey of visitor preferences by Confluence Research and Consulting, also conducted in 2012, found broad support for controlling river access in ecologically sensitive areas but also a strong preference for maintaining the overall accessibility and use of the river for all.

Other technical studies have been completed or are presently underway. The US Geological Survey developed a hydraulic model of the Merced River through Yosemite Valley in 2013, which by itself provides no particular guidance for restoration or identification of impacts, but which is a critical tool for evaluating the likely efficacy of any future restoration alternatives. A research team led by the University of California Santa Barbara is currently synthesizing and updating the prior information on the river, integrating that river-specific information within both the physical environment of the Merced River watershed and the social context of visitor experience and stakeholder preferences. A component of that UCSB-led effort is the design and implementation of a set of site-specific riparian restoration projects, with the first such project constructed in 2016 and a second planned for 2017. Subsequent future products of the research team will include a final synthesis of the physical condition and trajectory of the river and its watershed; a range of restoration alternatives that could improve physical, ecological, and aesthetic conditions throughout the river corridor through Yosemite Valley; and an evaluation of conditions and alternative restoration measures in the vicinity of Sugar Pine Bridge, a study specifically called for in the final Merced River Plan.

As a centerpiece of Yosemite Valley, the Merced River is at the heart of the visitor experience. It benefits from having a nearly pristine watershed, wholly contained within Yosemite National Park and largely protected in perpetuity by its wilderness status. The river itself is not unimpacted, but it is supported by intact watershed processes. When these processes are compromised, most critically the delivery of water and sediment from the watershed to the river, treatment of the channel itself may yield cosmetic benefits but they cannot be sustained without constant re-intervention. Where the impacts have occurred from local manipulation of and to the channel, however, then reversing those local effects is the correct fundamental approach to restoration. Such efforts should be successful, and they should persist, because the river is allowed to heal itself (Beechie, 2010; Kondolf, 2011), and its intact watershed can support such an outcome. This overarching principle—reversing past damage to the river itself to allow natural watershed processes to reassert their influence—constitutes the fundamental guidance for the restoration strategy for the Merced River in Yosemite Valley.

Upstream-looking view of the Merced River and Stoneman Bridge; Half Dome in the background.

The Society for Ecological Restoration (click for website) defines ecological restoration as "*the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed*." They go on to note that the value of restoration lies not only in the repair of ecological damage but also in its ability to improve the human condition. As such, it requires the integration of nature and culture, as well as drawing from both science and practice. This duality has been long-recognized in past efforts to identify and address the ecological impacts to the Merced River, and it continues to guide the current initiatives being pursued through Yosemite Valley today.

THE RESTORATION STRATEGY AND METHODS

The overarching goal of restoration of the Merced River is to protect and enhance the values for which the Merced River was designated a Wild and Scenic River, while providing for present and future public use and enjoyment of those river values. Given its intact watershed setting, restoration of the river in Yosemite Valley is focused on removing impediments to the natural expression of reach-scale hydrologic and geomorphic processes. These reach-scale processes include:

- The localized erosion, transportation, and deposition of sediment, and the expression of these processes in the form and shape of the river channel itself;
- The input, transport, and retention of organic material, particularly large wood; and
- The lateral inputs of water and sediment from upland runoff and tributary streams.

Although a river with intact watershed processes "should" trend towards a fully functional, restored state, not every human impact can be easily reversed by natural processes alone. Other impacts may be reversible but can require decades, centuries, or more to change. Finally, Yosemite Valley itself is not a pristine natural landscape, and meeting other goals (such as visitor access and enjoyment, or protection of cultural resources as well as natural resources) will require balancing potentially competing goals. These considerations suggest that the most successful outcomes can only be achieved through directed approach, rather than simply "letting nature take its course."

Four broad categories of restoration approach stand out as having the best opportunity to correct the critical impacts to the river through Yosemite Valley:

- **Restoration of dynamic river and tributary channels in Yosemite Valley**, important to allow the development of diverse, complex riparian habitats supporting successional vegetation in multiple stages. While processes such as channel migration and development of cut-off channels and meander belts undoubtedly affected the entire valley in prehistoric time, they can no longer have unfettered access to the entire landscape. The current constructed constraints on river-channel activity (e.g., armored banks), however, are more severe than strictly required by limitations of infrastructure, and they undoubtedly compromise the natural form and function of the river.

Bank armoring adjacent to Housekeeping Camp (river flow is towards the camera).

- **Encouragement of more frequent overbank flooding**, supporting a more natural and diverse assemblage of riparian plant species and thus improved riparian habitat for birds, amphibians, and mammals. This approach works in consort with others: overbank flooding encourages the development and expansion of tributary channels, and a dynamic river will invariably leave local areas more prone to overbank flows at lower discharges. Therefore, this approach is also subject to the same types of constraints to achieve a balance between expression of natural riverine processes and their enjoyment by visitors.

Side channel trending west off the mainstem Merced River, just upstream of Sugar Pine Bridge.

- **Creation of more complex in-channel habitat**, increasing the quality of aquatic habitat and therefore supporting an increased diversity of in-stream and riparian species. The natural shifting of channels and accumulation of large wood will tend to achieve this outcome regardless of further intervention. The rate of natural improvement, however, can be orders of magnitude slower than with well-directed restoration efforts, and so a passive approach could support a vision of "future" enjoyment but would preclude any "present" benefits. In some locations, the magnitude of human-constructed constraints and associated channel simplification may defy their destruction even over the very (very) long term by natural processes; for these, improvement will almost certainly require intervention through active restoration.

View upstream along the Merced River towards Housekeeping Camp footbridge.

Restoration of the riparian zone, including the reconstruction of streambanks trampled by unrestricted visitor access and reestablishment of a more diverse, native-species riparian vegetation community. As with the active re-creation of in-channel habitat, natural processes of vegetation succession and geomorphic adjustment would eventually achieve many of these goals, but the period of recovery without active intervention would likely extend for many decades or centuries.

Views of bank erosion. Clockwise from top left: downstream of Clarks Bridge, the riverbank along Upper Pines campground, along lower Tenaya Creek, between Stoneman Bridge and Housekeeping Camp

The following table summarizes the restoration approaches and specific types of actions that are being considered for implementation along the Merced River. They are listed in overall priority ranking, in recognition that direct impacts to the riparian zone and channel banks are not only the most pervasive throughout the Valley but also the most easily and inexpensively corrected. Those restoration approaches that require more extensive in-channel work, or that would require more extensive disturbance to adjacent floodplain areas, will demand a higher level of engineering design support and impose greater (albeit temporary) disturbance to both the landscape and visitors alike. Therefore, they are lower-priority approaches and are not yet fully developed as to conceptual design or identified potential localities for implementation.

Restoration approaches	**Actions**
1. Restoration of the riparian zone	● Revegetate riparian zone to increase channel roughness, induce sediment deposition, and promote the natural succession of native species ● Fence off bank areas vulnerable to trampling ● Remove unnecessary riprap, or failed riprap that causes increased erosion ● Place large wood structures along channel bank to limit erosion, accumulate sediment deposition, and promote revegetation of riparian species. ● Redirect flows to minimize bank erosion caused or exacerbated by bridges
2. Creation of more complex in-channel habitat	● Cease removal of large wood that naturally falls into the river; reposition, but not remove, wood between Clarks Bridge and Sentinel Beach where recreational rafting occurs consistent with Yosemite Superintendent's Directive 31 on large wood in management in the Merced River ● Add large wood or engineered large wood structures into the mainstem Merced River channel to increase habitat complexity and induce localized scour and sediment deposition ● Revegetate riparian and near-channel zone (as above)
3. Restoration of dynamic river and tributary channels in Yosemite Valley	● Remove riprap in non-essential locations, and/or replacement with bioengineered bank protection structures ● Add large wood or engineered large wood structures to the river channel (as above) ● Revegetate banks (as above) ● Redirect flows near bridges (as above)

Restoration approaches	Actions
4. Encouragement of more frequent overbank flooding and off-channel flows	● Increase in-channel roughness; narrow excessively widened channel reaches through riparian restoration and engineered large wood structures on the bank(see above) ● Restore ditched and graded meadows, and remove structures diverting groundwater ● Enhance existing or abandoned side channels to encourage more frequent overbank flooding ● Regrade selected floodplain areas to permit floodwater access at lower discharges

EXAMPLE RESTORATION ACTIONS

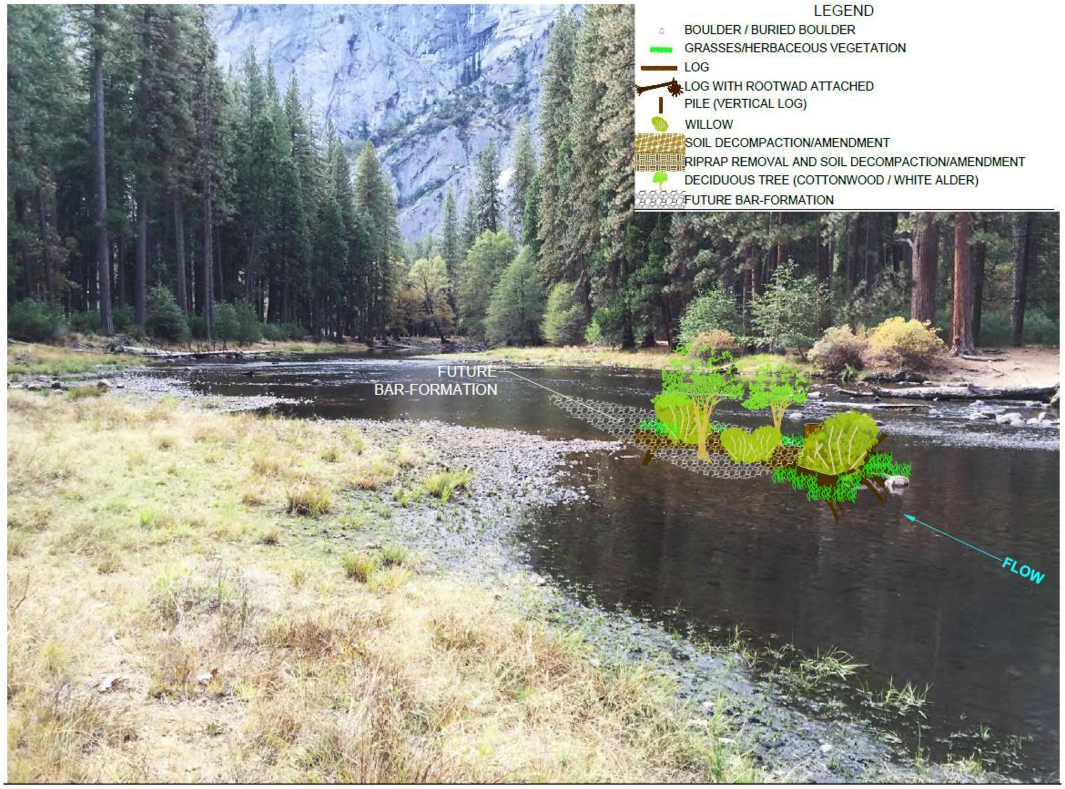
A variety of restoration techniques and actions can be used to achieve the desired outcome for each of the approaches outlined above. These actions almost always require site-specific designs, but some pictorial examples can nonetheless characterize how each of these approaches is commonly implemented and visualize the kinds of outcomes that can be anticipated.

1. Restoration of the riparian zone

Full or partial riprap removal and vegetation replanting to create a more diverse riparian zone:

2. **Creation of more complex in-channel habitat**

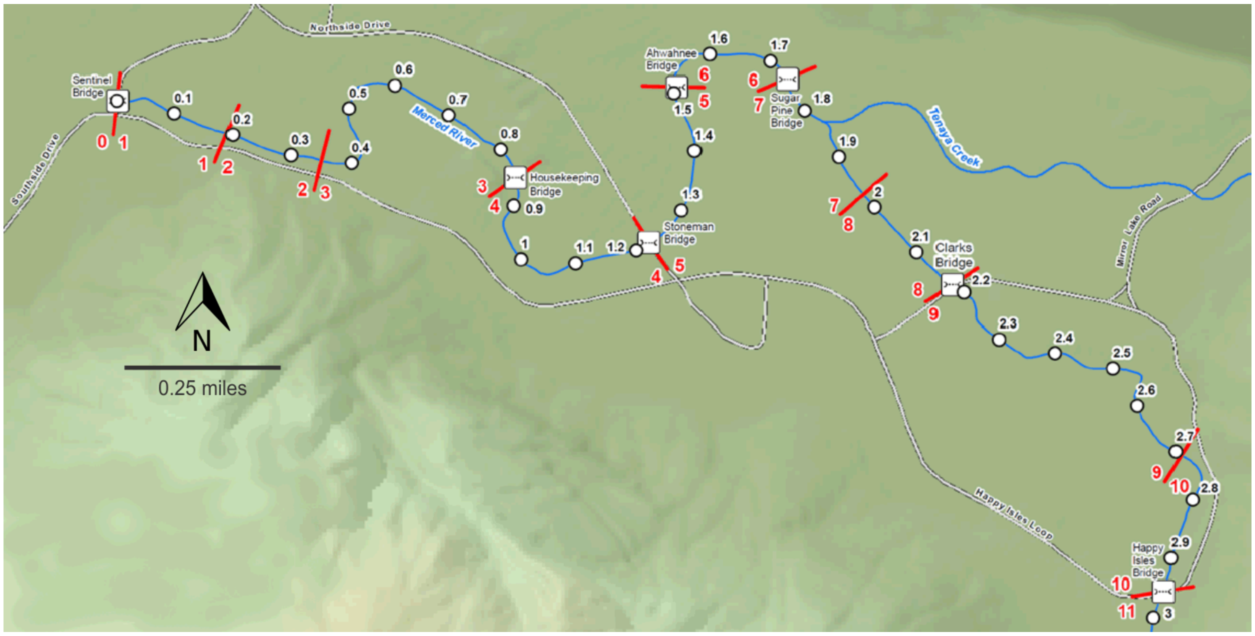
   In-channel large wood structures to create habitat diversity:



3. **Restoration of dynamic river and tributary channels in Yosemite Valley**
   Channel-narrowing treatment along trampled banks:

A REACH-BY-REACH OVERVIEW OF CONDITIONS AND RESTORATION OPPORTUNITIES

A preliminary evaluation of the three miles of the Merced River, between Happy Isle Bridge and Sentinel Bridge, has been conducted to identify the primary impairments to the river through the most intensively used portion of Yosemite Valley and to highlight where the different types of restoration treatments discussed above are most likely to be effective. At many sites, even a visual reconnaissance has proven sufficient to make firm recommendations for restoration design and implication; at other sites, the complexity of conditions or the risk to infrastructure will require more detailed analysis before firm recommendations can be made. The following discussion summarizes more detailed discussion and project examples in the Cardno, Inc. March 2016 report, *Merced River Riparian Corridor Restoration in Yosemite Valley*.



Index map of Merced River reaches (red numbers) discussed in the text. River miles (by 10ths of a mile) are shown by the white circles, measured upstream of Sentinel Bridge.

Reach 10 (downstream of Happy Isle Bridge; RM 2.95–2.71)

Three main issues provide the focus for restoration here: (1) unstable streambanks; (2) simplified vegetation structure; and (3) local downcutting with some exposure of bridge footings. Potential treatments primarily would involve removal of existing riprap, revegetation, and selective exclusion of human traffic from the riparian area. The downcutting adjacent to the bridge is potentially caused by the disconnection of high flow channels that once traversed the floodplain, such that now all flow at any discharge is directed down the main channel and through the bridge opening. At some point in the past, these high flow channels were blocked by large cobbles and boulders; restoration could involve reactivating these high flow channels through some combination of removing blockages and floodplain lowering. This would involve substantial earthwork activity, and so additional river modeling and engineering design would be required to inform any such design.

Reach 9 (upstream of Clarks Bridge; RM 2.71–2.18)

Issues within this reach include eroding streambanks and a riparian corridor with reduced structural complexity, species diversity, and functionality. Potential treatments would seek to reduce foot traffic with fencing or natural barriers where needed within the riparian corridor and along the banks and removal of the Upper Pines Dump Station (also proposed in the MRP). Restoration would include soil decompaction, regrading, and vegetation planting.

Reach 8 (downstream of Clarks Bridge; RM 2.18–1.97)

Issues here are similar to those in Reach 9, particularly associated with the North Pines and Lower River Pines campgrounds. Potential treatments that exclude and redirect river access to specified locations and revegetation and brush layering of willowswould enhance the riparian corridor and provide additional bank stability.

Reach 7 (Tenaya Creek confluence; RM 1.97–1.74)

Issues here are also similar to those in Reach 9, with additional erosion on the right streambank above Sugar Pine Bridge. Potential treatments to address channel widening and bank instability are similar to those recommended upstream. Restoration of historic swale features on the left floodplain, engineered features to direct flows, and floodplain grading represent progressively more intensive efforts that could help redirect high flows into overbank areas, enhancing floodplain function and the riparian corridor. Additional hydraulic modeling and engineering design would be required to inform any such design.

Reach 6 (Sugar Pine Bridge to Ahwahnee Bridge; RM 1.74–1.51)

This reach will be the subject of a subsequent, reach-specific study at a later stage in this project and so is not the subject of recommendations here.

Reach 5 (Ahwahnee Bridge to Stoneman Bridge; RM 1.51–1.22)

Issues within this reach include: (1) riparian corridor with reduced structural complexity, species diversity, and functionality; (2) eroding streambanks and over-widened channel; and (3) simplified channel morphology. To enhance the condition of the riparian corridor, general treatments such as fencing and hardened river access would limit and focus recreation access into appropriate locations. This reach is well-suited to a combination of bioengineered treatments to build floodplains, stabilize banks, and re-direct flows to address channel widening, local bridge-induced scour, and simplified channel morphology. This reach was the site of the first bank restoration project based on these recommendations; it was installed in the summer of 2016 along the right bank at RM 1.4 and is easily visible from Ahwahnee Bridge.

Reach 4 (Stoneman Bridge to Housekeeping Camp footbridge; RM 1.22–0.85)

This reach has been substantially impacted by human activity, and so the restoration needs and opportunities are similar to, but more extensive than, many of the reaches farther upstream. These include improving a riparian corridor that presently displays reduced structural complexity, species diversity, and functionality; and addressing streambank erosion and extensive riprap along the left streambank.Hardened river access to encourage recreation use in certain areas, regrading and pine tree removal, and replanting with native riparian species plantings within the floodplain would enhance the riparian corridor on the right streambank and floodplain; a variety of more intensive engineered structures along the left streambank will likely be required to enhance channel and riparian conditions while protecting valuable infrastructure. In these areas, additional hydraulic modeling and engineering design would be required to inform any such design.

Reach 3 (Housekeeping Camp footbridge to Housekeeping beach; RM 0.85–0.35)

Issues within this reach include localized streambank erosion, lateral confinement, and a disconnected floodplain. To address localized areas with streambank erosion, rock wall repair and streambank reconstruction with vegetation plantings would stabilize the streambanks. Opportunities for floodplain reactivation are present at two locations on the right floodplain where high-flow side channels are present; determining the potential value, persistence, and design of these features would require additional analyses.

Reach 2 (below Housekeeping beach; RM 0.35–0.19)

Issues within this reach include: (1) stormwater runoff from the adjacent road that flow into the river channel, causing streambank erosion and reducing water quality and (2) a riparian corridor along the left streambank with reduced structural complexity, species diversity, and functionality. Stormwater pretreatment would reduce localized erosion and improve water quality. Removal of non-native fill, re-contouring of the topography, and native vegetation planting along the right floodplain and streambank would enhance the quality of the riparian corridor. Although the left streambank riparian corridor is also confined and degraded, the need to protect existing infrastructure limits the feasibility of any treatments to address vegetation impacts there.

Reach 1 (upstream of Sentinel Bridge; RM 0.19–0.00)

Issues within this reach include unstable streambanks caused by recreation activity, an overly widened channel, a disconnected floodplain, and a riparian corridor with reduced functionality and structural complexity. To alleviate erosion caused by recreation use, hardened river access and riparian buffer enhancement with fencing would limit recreation access within the riparian corridor. Streambank reconstruction would stabilize the streambank and enhance the riparian corridor. Improved in-channel complexity could be achieved through a combination of mid-bar-forming engineered log features and lowering of the right streambank to reconnect the floodplain. Additional modeling analyses would be required prior to design of these two potential treatment concepts to determine their value and design.